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# The Nominal Facts and the October 1979 Policy Change

**William T. Gavin and Finn E. Kydland**

There is a consensus concerning business cycle facts when the facts are about real variables. For example, Backus and Kehoe (1992) note that there is a similarity among covariance structures of real time series taken from different countries and from different sample periods within a country. This consistency across data sets is no doubt one reason for the large amount of research on real business cycles.

This consistency does not extend to data sets that include money and prices. Backus and Kehoe (1992) found that the cyclical properties of money and prices were unstable across historical periods and across countries. Rolnick and Weber (1997) noted that the time-series properties of prices and money are very different in economies with commodity money standards than they are in economies with fiat money standards. Kydland and Prescott (1990) noted disagreement among economists about the cyclical patterns in prices. Wolf (1991), Cooley, and Ohanian (1991), and Pakko (2000) show that the cyclical behavior of prices in the United States varies from one episode to the next. Several researchers have attributed this instability to changing policy regimes. For example, Friedman and Kuttner (1992) found that nominal-real relationships deteriorated following the Fed's policy change in 1979:Q3. Bryan and Gavin (1994) and Gavin and Kydland (1999) show that the correlations involving nominal variables of U.S. data are very different in the period from 1959:Q1 to 1979:Q3 than they are in data sets that begin in 1979:Q4.

Although economists looking for business cycle facts have tended to combine data across policy regimes and ignore the instability across the October 1979 policy change, many empirical research studies have limited their data to the post-1979 era.[1] Also, many business economists have stopped using the pre-1980 data in the financial sector equations of forecasting models.[2] Naturally, the instability caused by the policy shift is most acute in modeling the monetary policy reaction function. Empirical work in this area has been more careful about the break in the covariance structure associated with policy changes. Empirical studies on policy rules tend to split the sample in 1979 or to use data series beginning sometime after October 1982 when the nonborrowed reserve operating procedure was abandoned. See, for example, work by Coleman, Gilles, and Labadie (1993), Taylor (1993), Clarida, Gali, and Gertler (1998), Judd and Rudebusch (1998), Rudebusch and Svensson (1999), McNees (1992), Mehra (1999), Kozicki (1999), Salemi (1995), and many of the studies in Taylor (1999).

Our goal is to document the nominal facts using as little theory as possible. Gavin and Kydland (1999) calculated the cyclical properties of money and prices for the periods before and after the October 1979 policy change. In this article, we extend that work in several ways. We add four more years of data, and we examine the cyclical properties of nominal interest rates and inflation. Finally, we examine the covariance structure of several nominal relationships: the autocovariance of inflation, the lag from money growth to inflation, and the lag from money growth to nominal gross domestic product (GDP) growth.

In the first part of the paper, where we examine cyclical facts, we transform the data using the Hodrick-Prescott (H-P) filter. We have detrended all the series, including those for inflation and interest rates. We construct the trends using data from the full sample, 1959:Q1 to 1998:Q4, even in cases where we think there may be important breaks in the series, partly because we cannot be certain whether important breaks in the series do exist. Furthermore, even if such breaks exist, the problems in measuring the trend at the endpoints may be worse than the use of data across regimes. Throughout this first section of the paper, when we refer to a time series

[1] Kydland and Prescott (1990), Cooley and Hansen (1995), Fuhrer and Moore (1995), and Stock and Watson (1999) report statistics on the cyclical properties of nominal variables using data sets that span the October 1979 policy shift.

[2] See, for example, the forecasting model of Macroeconomic Advisors, LLC, in which the term structure equation and monetary policy reaction function are estimated using only post-1982 data.

such as a monetary aggregate, GDP, or a price index, we are talking about the deviation of the logarithm of the variable from the H-P trend. Because there is some question about whether inflation rates and interest rates should be detrended, we also look at the cyclical properties of these series without filtering them.

The next section of the article looks at nominal growth rates. We do not use the H-P filter because we believe that, under fiat money standards, the interesting information in nominal data is the trend induced by monetary policy. Although the Fed may have accommodated cyclical demands for money and credit, the behavior of inflation shows that the Fed has induced a long cycle that spans several business cycles. Figure 1 shows the consumer price index (CPI) inflation between 1959:Q2 and 1998:Q4. There was a long period of rising inflation from the beginning of our sample until the end of the 1970s. The inflation rate dropped rapidly in the three years beginning in 1979:Q4. Since then, the Fed seems to have followed a policy of maintaining inflation along a moderate and slightly declining trend.

## THE MONETARY POLICY REGIME SHIFT IN OCTOBER 1979

We find a different set of empirical regularities for post-October 1979 than we find for the pre-October 1979 period. It is useful to make a distinction between changes in the way the monetary policy decisions are made at Federal Open Market Committee (FOMC) meetings and changes in the way FOMC decisions are implemented by the Open Market Desk (Desk) at the Federal Reserve Bank of New York. In October 1979, both types of changes were made. After October 1979, the FOMC apeared to make policy decisions with more concern about deviations of inflation from the implied objective than they had before October 1979.[3] The FOMC also changed the procedures the Desk used to implement the decision made at the meeting.

### *FOMC Decision Making*

The FOMC sets the target for the policy instrument at FOMC meetings. This is a decision about where to locate the money supply function. The decision, both before and after the October 1979 policy change, was to supply reserves to lead to desired outcomes for inflation and output growth. Each decision was also expected to result in particular outcomes for the federal funds rate and the growth in the targeted monetary aggregates, particularly M1. A combination of theory, econometric models, and judgment went into these decisions. Before October 1979, monetary policy resulted in a high and variable outcome for inflation. After October 1979, the FOMC appeared to put relatively more weight on controlling money growth and inflation.[4] Gavin and Kydland (1999) show that shifts of this sort would be expected to lead to significant shifts in the cyclical properties of nominal variables. This is the case whether or not the FOMC changes the way it implements the policy decision (its operating procedure).

### *The Operating Procedures*

At the same time that it announced a new commitment to reducing money growth and inflation, the FOMC announced a change in the way the Desk would implement the decisions made at FOMC meetings.[5] Prior to October 1979, the FOMC decided on a target for the federal funds rate—the market interest rate on overnight lending between banks. The FOMC would direct the manager of the System Open Market Account to buy and sell securities to maintain the interest rate near the target level. At each FOMC meeting, the staff of the Board of Governors would present the committee with estimates of how much money growth to expect from the alternative federal funds target choices. During the intermeeting period, surprises in the demand for reserves would be accommodated so that surprises in money demand showed up as variability in the quantity rather than the price of reserves.

On October 6, 1979, Fed Chairman Paul Volcker announced that the procedure would be changed so that the manager of the Desk would be required to adjust the Fed's portfolio of securities to achieve weekly targets for nonborrowed reserves, rather than the federal funds rate. The policy change led to a dramatic, tenfold increase in the volatility of the federal funds rate and a high correlation among changes in interest rates across the term structure and across national boundaries. The increased

[3] See Clarida, Gali, and Gertler (1998), McNees (1992), Salemi (1995), and Chapter 7 in Taylor (1999) for econometric evidence about the Fed's reaction function in the two periods. All find a significant increase in the Fed's relative concern about inflation after October 1979.

[4] See references cited in footnote 3.

[5] See Gavin and Karamouzis (1985) for an elementary description of the alternative operating procedures.

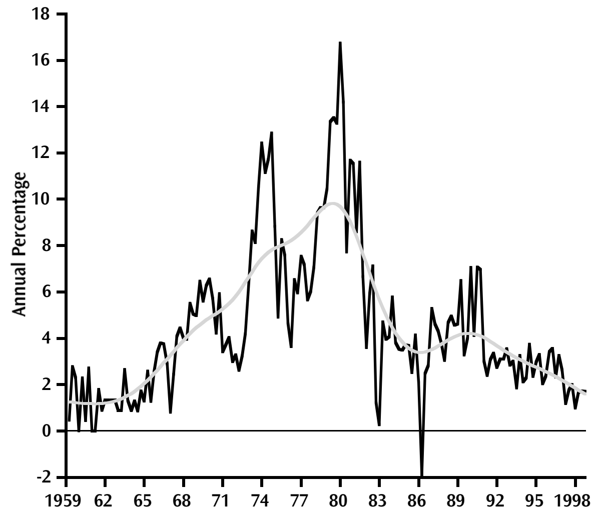
interest rate volatility caught the attention of the markets and the public. It probably helped Paul Volcker achieve credibility for the disinflation policy. Although inflation fell to around 4 percent at the end of 1982, M1 demand became more unstable, so the Fed shifted to borrowed reserves and returned to an operating procedure that was an indirect form of interest rate targeting.[6] In Alan Greenspan's first term as Fed Chairman (which began in 1987), the FOMC returned to an explicit interest rate targeting procedure.

The change in the operating procedure had a predictable effect on the volatility of interest rates. We think it is important to consider the interest rate correlations without the subperiod of reserve targeting. During this period the variation in interest rates associated with the operating procedure was large relative to variation in interest rates coming from other sources. However, this three-year period also included the longest and largest recession of the post-WWII era, so we are reluctant to exclude that period in all of our investigations. We note that none of the major results about the money stock, inflation, or the real economy would be qualitatively different if we had excluded that period from the analysis. In general, we think that the high-frequency correlations that are important for understanding financial markets would be affected by the operating procedure, but they are not the focus of this article. In our judgment, the cyclical effect of changes in the monetary policy decision-making process, even under very different procedures for implementing the decisions, will impact the aggregate price, money, and output data at business cycle frequencies in a similar manner. The effect of alternative operating procedures on the variability of interest rates was dramatic. However, the short period and severe recession that occurred during the period of nonborrowed reserve operating procedure makes it difficult to say whether the operating procedure had any effect on the cyclical behavior of interest rates.

We begin by reviewing the business cycle facts for the real variables and show that the covariance structure is relatively stable across the October 1979 policy change. Next, we examine the changes in the cyclical behavior of the monetary aggregates. Here the results are quite spectacular. There are dramatic changes in the behavior of all the monetary aggregates. Then we look at measures of the price level and inflation. Here the results for inflation are almost as dramatic as for the monetary aggregates, but the results for the price level are not. Next, we find that the cyclical behavior of nominal interest rates looks much like the behavior of inflation, suggesting that the expected inflation premium dominates the real interest rate as a source of cyclical variation in nominal rates. Finally, we examine the covariance structure among some nominal variables: the persistence of inflation as reflected in its autocovariance structure, the cross-correlations between inflation and money growth, and the cross-correlations between growth rates in nominal GDP and four definitions of the money supply.

**Figure 1**

**CPI Inflation and H-P Trend**




## CYCLICAL PROPERTIES OF NOMINAL TIME SERIES

In Gavin and Kydland (1999), we found that changes in monetary policy affect the cyclical properties of nominal time series much more than they affect the cyclical properties of real time series. Before looking at the cyclical patterns in nominal variables, we begin by reviewing the cyclical behavior

[6]See Thornton (1988) for an empirical analysis of the distinction (and similarities) between the Borrowed-Reserve operating procedure adopted in 1982 and an interest rate procedure.

of the real variables. There are two differences from the work presented in our earlier paper. First, we use business sector output rather than GDP as the measure of output. Business sector output is the measure of output used by the Bureau of Labor Statistics to report on labor productivity. The other difference is that we have extended the data set by adding quarterly data for the years 1995 through 1998.

We decided to use business sector output because it is the measure used to calculate productivity and it corresponds more closely with the concept of output that we typically use in macroeconomic theories. Using a different measure of output and adding four years to the sample do not change the results reported in our earlier paper. The cross-covariance structure among the real variables we examine—real business sector output, personal consumption expenditures, expenditures on durables, expenditures on nondurables and services, domestic fixed investment, hours worked, and productivity—appears to be largely unchanged across the October 1979 shift in monetary policy.

Figure 2 shows the cyclical patterns of real variables for the two periods. We measure cyclical patterns as correlations with the deviations of output from trend. For both of these periods and despite differences in data and time periods, the correlation coefficients are quite similar to those reported by Gavin and Kydland (1999) and earlier by Kydland and Prescott (1990). Hours worked as well as the components of consumption and investment are highly procyclical. There does appear to be a change in the cyclical behavior of productivity; it leads the cycle by two quarters in the earlier sub-sample, but appears coincident in the later period.

The last panel in the bottom right hand corner of Figure 2 shows the standard deviations for each of the variables over the separate periods. Consumption of nondurables and services is less variable than output, whereas expenditures on durables and all the components of investment are much more variable than output in percentage terms. In each case, the standard deviation is lower during the period following October 1979.[7] The biggest decline was in the standard deviation of productivity growth which was one third lower during the second period.

Table 1 presents evidence about the statistical significance of the differences in the correlation coefficients across sample periods. We constructed a Wald test to compare the null hypothesis—that the correlation coefficient in the latter period is equal to the correlation coefficient in the earlier period—with the alternative hypothesis that they are not equal.[8] If the two data series are treated as random samples drawn from a bivariate normal distribution, then the Wald statistic has a chi-square distribution with one degree of freedom. The 10 percent critical value is 2.71. Of the 77 statistics in the panel, 10 are equal to or greater than 2.71. That is, for 67 of the 77 statistics compared in Table 1, the evidence suggests that the behavior of real variables in the second half of the full sample is the same as that in the first half.

There is some doubt about whether the macroeconomic variables can be assumed to follow a normal distribution—an important assumption for the reliability of the Wald test. We use a Monte Carlo method to check the reliability of the Wald test. We constructed small-sample critical values from 1000 repetitions of the following experiment. Using actual data from the earlier period (not deviations from trend), we estimated a bivariate vector autoregression that includes business sector output and one of each of the other variables. In every case, we recovered estimates of autoregressive parameters and the covariance matrix. Then these estimates were used with a random number generator to create 1000 artificial series for each pair. Each series is 160 periods long. These series were then detrended, the sample split at period 83 (corresponding to 1979:Q3 in the U.S. sample), and the cross-correlations calculated for each period. For each artificial series, the Wald test was constructed to determine stability across the two periods. The 1000 test statistics were sorted by size, and the one-hundredth largest is reported in parentheses below the Wald statistic. In every case for the real variables, the 10 percent critical value generated by this Monte Carlo method was larger than the asymptotic value implied by the bivariate normal assumption (2.71). This alternative testing procedure makes it more difficult to reject the null hypothesis, thus the conclusions regarding the changes in cyclical behavior have a conservative bias. In Table 1, you can see that the simulated small-sample 10 percent critical value is always larger than the Wald statistic calculated using actual data. Using this Monte Carlo distribution with the real variables, we cannot reject the null hypothesis that the same process generated the cross-correlations from both periods.

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[7] See McConnell and Quiros (2000) for a discussion of the decline in output volatility after 1984.

[8] See Ostle (1963), pp. 225-7, for a detailed description of the test statistic used.

**Figure 2**

**Cyclical Properties of Real Variables**

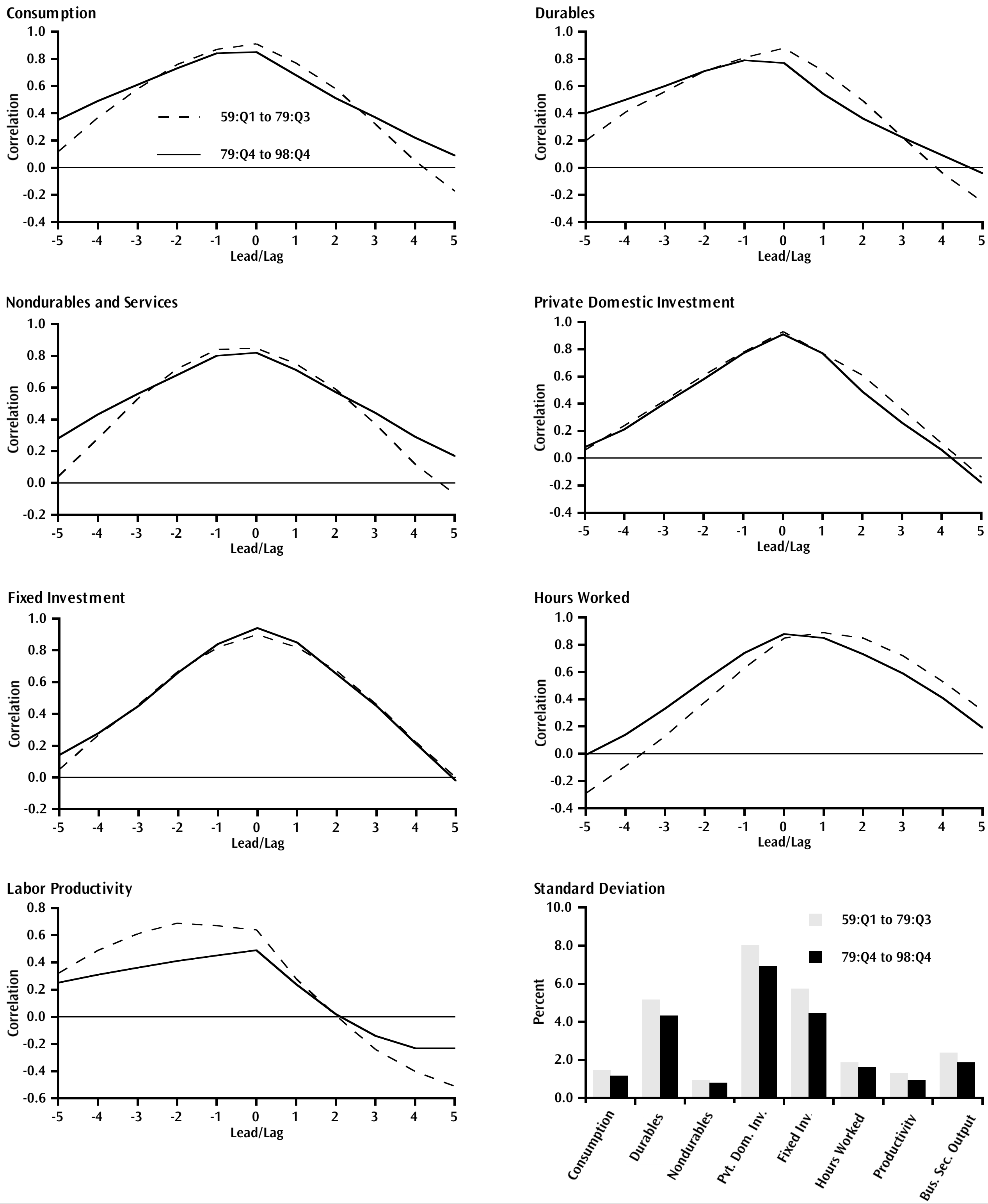


**Table 1**

**Stability Tests for the Cyclical Properties of Real Variables**

| Variable X | $X_{t-5}$ | $X_{t-4}$ | $X_{t-3}$ | $X_{t-2}$ | $X_{t-1}$ | $X_t$ | $X_{t+1}$ | $X_{t+2}$ | $X_{t+3}$ | $X_{t+4}$ | $X_{t+5}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Chi-square test for equality of correlations across sample periods (1959:Q1 to 1979:Q3 and 1979:Q4 to 1998:Q4) | | | | | | | | | | |
| Consumption | 2.22 | 0.82 | 0.07 | 0.22 | 0.74 | 2.76 | 1.49 | 0.34 | 0.09 | 1.15 | 2.41 |
| | (5.10) | (5.09) | (5.51) | (6.85) | (8.92) | (9.07) | (5.50) | (5.06) | (5.27) | (6.17) | (6.81) |
| Durables | 1.72 | 0.51 | 0.12 | 0.00 | 0.16 | 4.08 | 3.07 | 0.97 | 0.00 | 0.63 | 1.73 |
| | (5.69) | (5.01) | (5.02) | (6.08) | (7.55) | (7.63) | (5.33) | (5.20) | (5.53) | (6.19) | (6.93) |
| Nondurables and Services | 2.31 | 1.12 | 0.10 | 0.33 | 0.59 | 0.34 | 0.25 | 0.05 | 0.25 | 1.17 | 2.13 |
| | (4.82) | (4.31) | (4.31) | (5.38) | (7.94) | (9.86) | (8.04) | (7.63) | (7.47) | (7.79) | (8.22) |
| Private Domestic Investment | 0.02 | 0.04 | 0.04 | 0.12 | 0.04 | 0.64 | 0.00 | 1.04 | 0.45 | 0.10 | 0.06 |
| | (5.97) | (5.65) | (5.71) | (6.07) | (6.48) | (7.35) | (4.83) | (3.00) | (2.90) | (2.99) | (3.80) |
| Fixed Investment | 0.32 | 0.01 | 0.01 | 0.02 | 0.16 | 2.95 | 0.27 | 0.06 | 0.01 | 0.00 | 0.01 |
| | (6.66) | (6.11) | (6.47) | (7.10) | (8.51) | (11.00) | (7.76) | (5.70) | (4.70) | (4.81) | (5.22) |
| Hours Worked | 3.13 | 2.15 | 1.62 | 1.52 | 1.44 | 0.59 | 0.97 | 3.73 | 2.13 | 1.01 | 0.76 |
| | (4.27) | (4.15) | (3.91) | (3.84) | (3.66) | (4.36) | (10.10) | (10.53) | (8.97) | (8.30) | (7.61) |
| Productivity | 0.19 | 1.80 | 3.88 | 6.59 | 4.11 | 1.71 | 0.07 | 0.00 | 0.44 | 1.35 | 4.03 |
| | (10.26) | (10.77) | (10.73) | (8.21) | (5.12) | (3.25) | (3.12) | (3.57) | (4.28) | (4.40) | (4.67) |

NOTE: Simulated 10% critical values are shown in parentheses. The light shading indicates that the chi-square test statistic rejects stability at the asymptotic 10% critical value (2.71).

## *Money*

In contrast to the real variables we examined in the previous section, the monetary aggregates behaved very differently during the period after October 1979 than they did before. We have included analysis of four alternative measures of the money supply. The narrowest aggregate included was the Federal Reserve Bank of St. Louis's adjusted monetary base (SL Base) as revised by Anderson and Rasche (1996). The transactions aggregate we included was money with zero maturity (MZM) rather than M1 because it includes the sweep accounts that distort the M1 data after 1994; MZM is defined as M2 minus small denomination time deposits, plus institutional money market mutual funds. This aggregate was proposed by Motley (1988) and the label was coined by Poole (1991). Finally, we included M2, which is the Fed's primary monetary target and the M2 monetary services index (MSIM2) as constructed by Anderson, Jones, and Nesmith (1997).

The bottom panel of Figure 3 shows the standard deviation of the alternative measures of the money stocks for the two sub-samples. Substantial changes occurred in the variability of the monetary aggregates around trend. The narrow aggregates—SL Base and MZM—are less variable before 1979:Q3 than afterward, whereas the broad monetary aggregates—M2 and MSIM2—become less variable in the latter period.

There were also large changes in the cyclical correlations shown in Figure 3. Before October 1979, all four of the monetary aggregates were highly procyclical. The procyclical behavior practically disappeared in the second period. The contemporaneous correlation of the monetary base with real GDP falls from 0.47 to 0.11. The contemporaneous correlation of M2 drops dramatically, from 0.64 to

## Table 2

### Stability Tests for the Cyclical Properties of Monetary Aggregates

Chi-square test for equality of correlations across sample periods (1959:Q1 to 1979:Q3 and 1979:Q4 to 1998:Q4)

| Variable X | $x_{t-5}$ | $x_{t-4}$ | $x_{t-3}$ | $x_{t-2}$ | $x_{t-1}$ | $x_t$ | $x_{t+1}$ | $x_{t+2}$ | $x_{t+3}$ | $x_{t+4}$ | $x_{t+5}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SL Base | 11.27 | 7.21 | 2.02 | 0.00 | 1.72 | 6.05 | 13.72 | 20.84 | 18.10 | 18.92 | 19.22 |
| | (8.31) | (8.36) | (8.47) | (9.13) | (9.32) | (9.40) | (9.43) | (9.71) | (10.09) | (11.29) | (11.65) |
| MZM | 0.03 | 1.29 | 8.28 | 14.90 | 15.35 | 15.22 | 12.71 | 7.81 | 2.75 | 0.82 | 0.30 |
| | (12.68) | (11.66) | (11.68) | (13.43) | (12.84) | (10.33) | (8.40) | (8.18) | (8.66) | (10.01) | (10.52) |
| M2 | 2.31 | 9.87 | 24.29 | 34.62 | 31.14 | 20.57 | 10.82 | 2.54 | 0.07 | 2.46 | 9.82 |
| | (8.41) | (9.18) | (10.01) | (10.80) | (9.85) | (8.00) | (7.32) | (7.27) | (8.62) | (9.53) | (10.31) |
| MSIM2 | 8.54 | 20.71 | 40.72 | 54.09 | 40.89 | 19.80 | 5.44 | 0.01 | 6.84 | 19.44 | 32.99 |
| | (9.63) | (9.23) | (10.05) | (11.56) | (10.09) | (8.05) | (7.06) | (7.33) | (8.07) | (9.70) | (10.94) |

NOTE: Simulated 10% critical values are shown in parentheses. The light shading indicates that the chi-square test statistic rejects stability at the asymptotic 10% critical value (2.71). The dark shading indicates that the chi-square test statistic is larger than the simulated 10% critical value.

0.02. A similar drop occurred with the newer measures, MZM and MSIM2.

Other than the dramatic change in contemporaneous correlations, there are few patterns shared by the cyclical behavior of the aggregates. In the earlier period, the SL Base lagged behind the cycle in output; after October 1979, it led the cycle by about a year. MZM and M2 led the cycle in both periods. The cyclical pattern for M2 before October 1979 was essentially the same as the cyclical pattern for MSIM2. But afterwards, they are quite different. Since then, M2 has led the cycle weakly while MSIM2 has lagged by two to five quarters.

The most important similarity among the monetary aggregates is that they all appear to be unstable across the policy regime switch in 1979.[9] In Table 2 we see that 32 of the 44 cross-correlations are greater than the theoretical asymptotic critical value, 2.71. Using this test, we can reject the hypothesis that the cyclical patterns were the same for all four definitions of money that we considered. When we compare the Wald statistics calculated from the data with the more conservative critical values from our Monte Carlo distributions (shown in parentheses in the bottom panel), we still find that 24 of the 44 are larger than the 10 percent critical values. Clearly, the cyclical properties are different in the two periods.

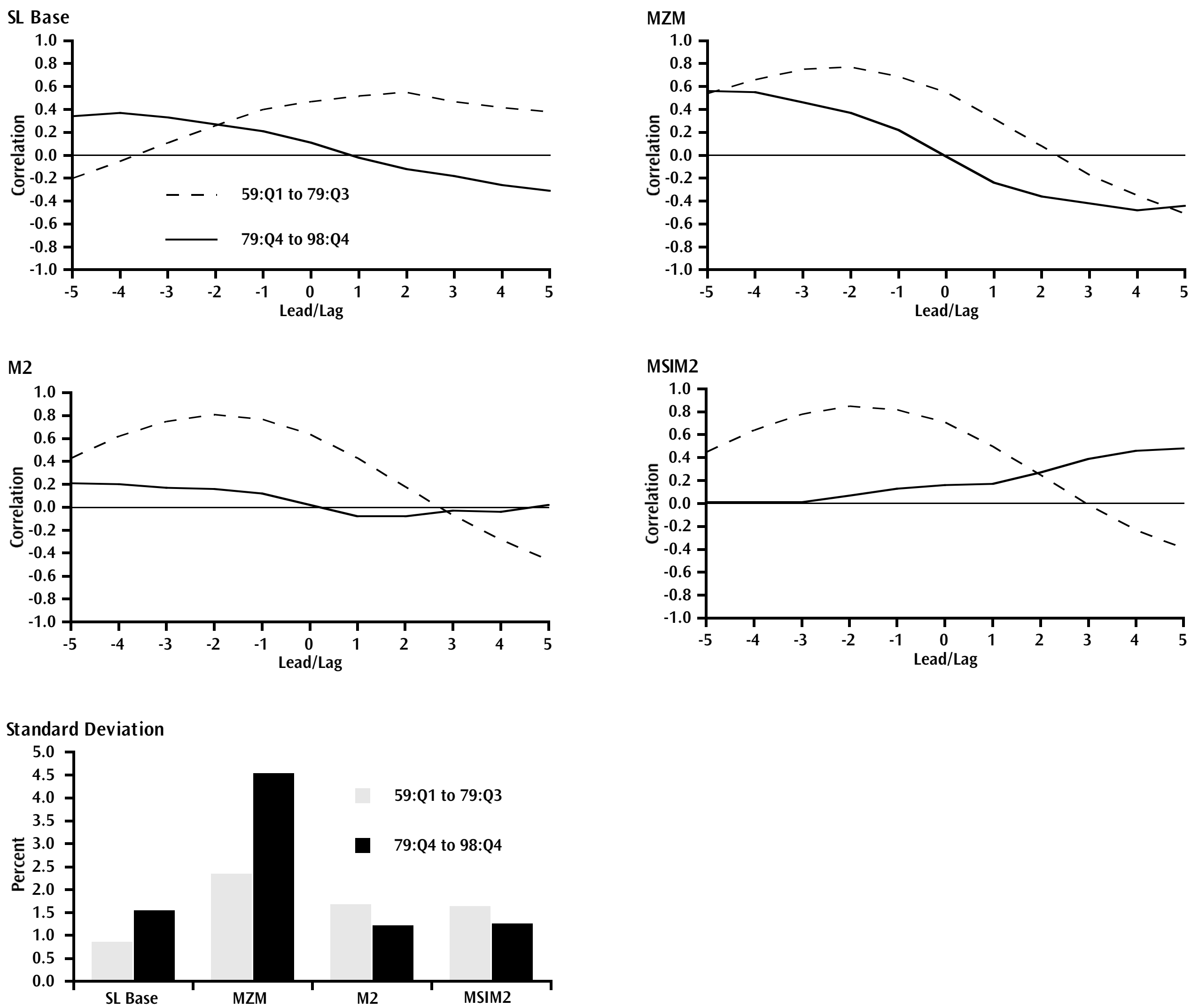
## *Prices and Inflation*

Figure 4 shows the cyclical patterns for the price level measured by the CPI and the chain price indexes for personal consumption expenditures (PCE) and GDP. All display a similar pattern and a similar change after October 1979. The contemporaneous correlation in the earlier period was approximately −0.8 and rose by about 0.3 in the second period. The consumer price measures lead output—with a negative sign—by two quarters in the earlier period and by four quarters in the latter period. The GDP chain price index appears to lead—again with a negative sign—by about one quarter in the earlier period and three quarters in the second period. Table 3 reports the tests for stability of the cross-correlations. We find that price and output correlations across the two periods are significantly different if we use the asymptotic 10 percent critical value (2.71). Using the more conservative tests, we cannot reject the hypothesis that the price-output correlations are the same across the policy regime switch. Note that this result changed after we added data for the four years 1995 through 1998. In Gavin and Kydland (1999), we found that

[9] Friedman and Kuttner (1992) also have documented the instability in the monetary aggregates across the 1979 policy regime switch.

**Figure 3**

### Cyclical Behavior of the Monetary Aggregates



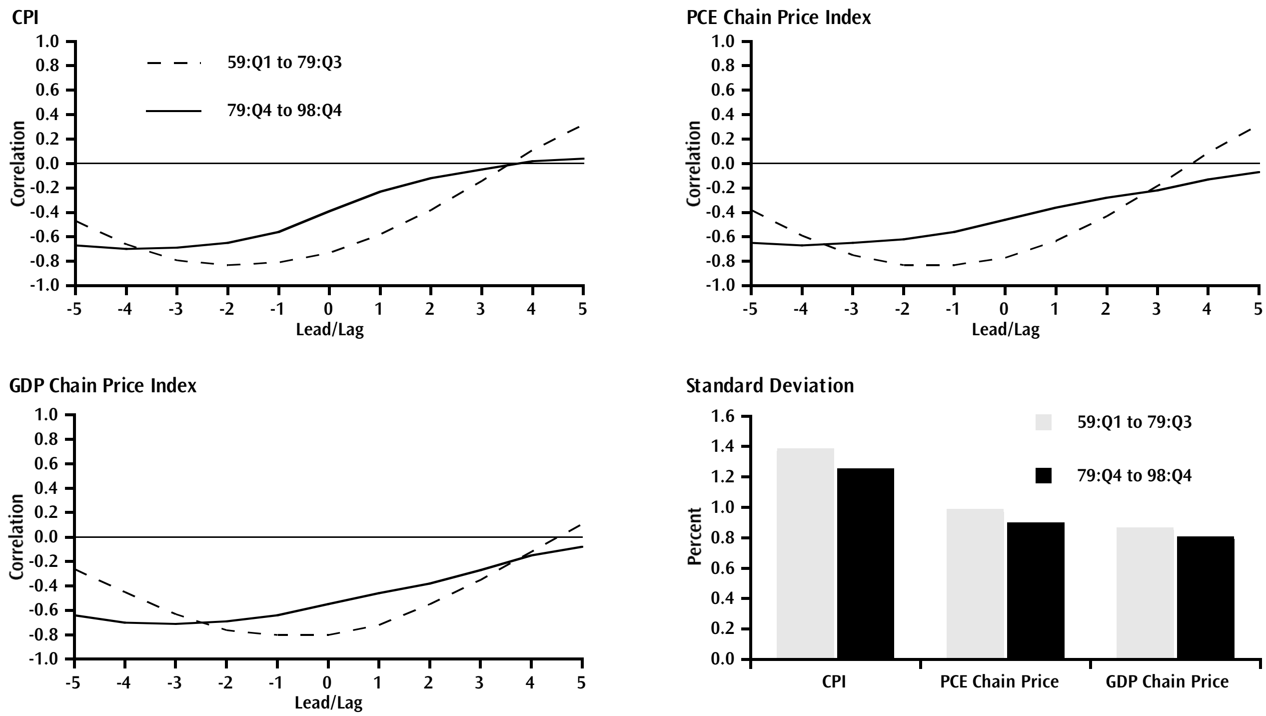

some of the cross-correlations were significantly different for both the CPI and the GDP deflator even when we used the more conservative simulated critical values.

The standard deviations for the price level (shown in the bottom right-hand panel of Figure 4) were slightly lower, on average, during the period following 1979 than they were in the period from 1959:Q1 through 1979:Q3. Note, as depicted in Figure 1, the second period average masks a substantial dampening of the variability of inflation throughout the period. There was a dampening of inflation volatility after 1982 and another, more obvious, decline in the 1990s.

Figure 5 shows the cyclical properties of the different inflation rates when measured as deviations from the H-P trend. King and Watson (1994) noted that there was strong evidence of a Phillips curve relationship between the cyclical components of inflation and unemployment. Here we have used detrended output rather than the deviations of unemployment from trend. As suggested by the King and Watson paper, the contemporaneous correla-

## Figure 4

### Cyclical Properties of the Price Level




## Table 3

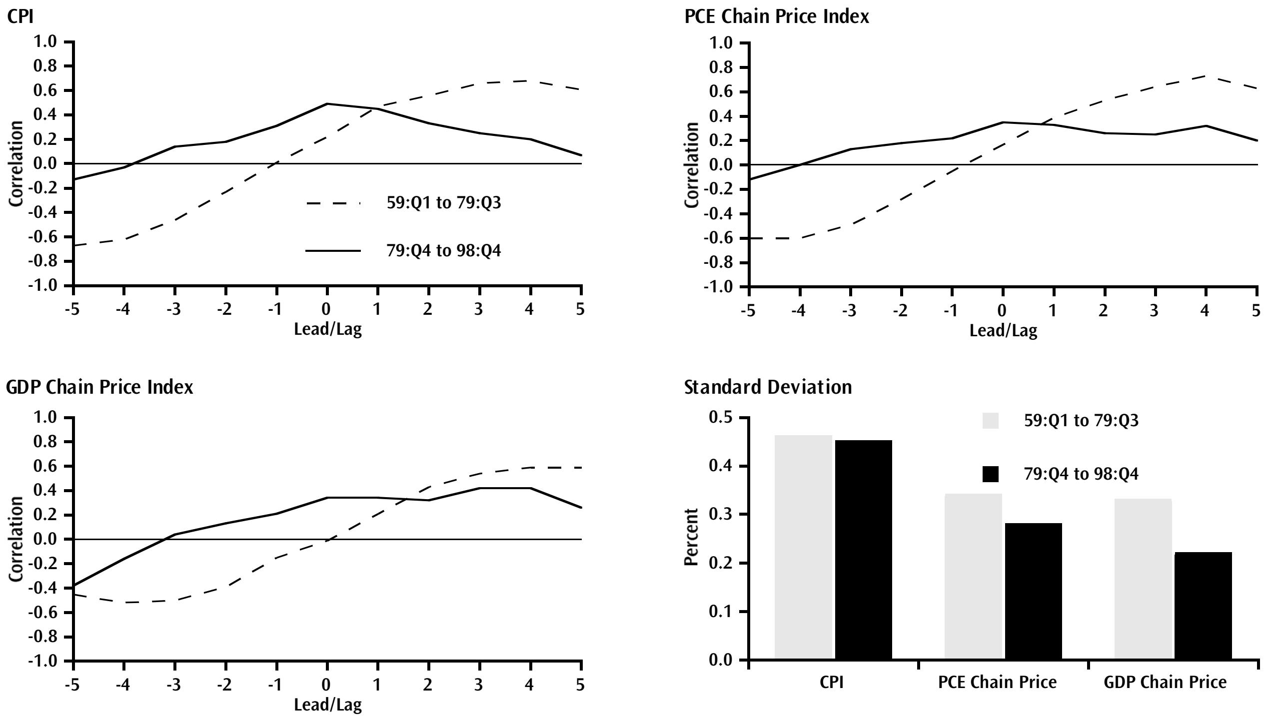
### Stability Tests for the Cyclical Properties of the Price Level

| Variable X | $X_{t-5}$ | $X_{t-4}$ | $X_{t-3}$ | $X_{t-2}$ | $X_{t-1}$ | $X_t$ | $X_{t+1}$ | $X_{t+2}$ | $X_{t+3}$ | $X_{t+4}$ | $X_{t+5}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Chi-square test for equality of correlations across sample periods (1959:Q1 to 1979:Q3 and 1979:Q4 to 1998:Q4) | | | | | | | | | | |
| CPI | 3.27 | 0.27 | 1.87 | 6.96 | 9.84 | 10.74 | 6.94 | 2.78 | 0.29 | 0.30 | 3.11 |
| | (8.03) | (10.07) | (13.63) | (16.29) | (15.51) | (12.35) | (7.41) | (6.13) | (5.71) | (6.29) | (7.34) |
| PCE Chain | 5.11 | 0.63 | 1.39 | 8.45 | 11.81 | 10.31 | 5.09 | 1.04 | 0.05 | 1.75 | 5.98 |
| Price Index | (7.43) | (8.61) | (11.44) | (19.19) | (24.06) | (22.47) | (12.64) | (8.76) | (6.53) | (6.47) | (7.50) |
| GDP Chain | 8.88 | 5.53 | 0.75 | 0.96 | 4.62 | 8.65 | 6.07 | 1.91 | 0.31 | 0.02 | 1.45 |
| Price Index | (9.28) | (9.25) | (10.33) | (12.36) | (15.82) | (19.78) | (14.09) | (9.94) | (7.82) | (7.27) | (6.91) |

NOTE: Simulated 10% critical values are shown in parentheses. The light shading indicates that the chi-square test statistic rejects stability at the asymptotic 10% critical value (2.71).

**Figure 5**

**Cyclical Properties of Inflation with H-P Filter**




tion between deviations of inflation from the H-P trend and business sector output was positive in both periods for the consumer based measures. The cross-correlation with CPI inflation approximately doubled, rising from 0.22 in the pre-October 1979 period to 0.49 in the latter period. The correlation between inflation using the GDP chain price index and output rose from −0.01 in the earlier period to 0.34 in the latter period. Although the contemporaneous correlations are larger in the second period, the correlations are smaller at longer leads and lags. The top panel of Table 4 shows the Wald statistics and the simulated 10 percent critical values for testing the hypothesis that the correlations are equal across periods. Here, 25 of the 33 cross-correlations display a significant change when we use the asymptotic critical value. When we use the more conservative small sample critical values, we still find that 22 of 33 are significant.

Figure 6 depicts the cross-correlations between detrended output and inflation without the H-P filter. This third method of comparing output and inflation corresponds to a common specification of these variables, as they typically appear in the aggregate supply function of macroeconomic models used by policymakers and their advisors. Inflation is slightly more variable if we do not remove the trend. There is a decline in variability of all three measures of inflation across the date of the policy regime switch. Using the H-P filter has a large effect on the measure of cyclical behavior. In Figure 5, where inflation was filtered, we reported large negative leads in the early period that became smaller in absolute value in the later period. In Figure 6, where inflation was not filtered, the negative leads are smaller in the first period, especially for the GDP chain price index. However, in the second period, the negative leads are larger in absolute value if we do not filter the data. The bottom panel of Table 4 shows the results when the data are not filtered. The only lead that has a significant change using the asymptotic critical value is for the GDP chain price index at a lead of five quarters. The lagged correlations are smaller in both periods if we do not filter the data,

## Table 4

### Stability Tests for the Cyclical Properties of Inflation

| Variable X (H-P filtered inflation) | $X_{t-5}$ | $X_{t-4}$ | $X_{t-3}$ | $X_{t-2}$ | $X_{t-1}$ | $X_t$ | $X_{t+1}$ | $X_{t+2}$ | $X_{t+3}$ | $X_{t+4}$ | $X_{t+5}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Chi-square test for equality of correlations across sample periods (1959:Q1 to 1979:Q3 and 1979:Q4 to 1998:Q4) | | | | | | | | | | |
| CPI inflation | 16.86 | 17.98 | 15.40 | 6.44 | 3.71 | 3.54 | 0.03 | 3.21 | 10.38 | 14.71 | 15.21 |
| | (6.69) | (5.07) | (4.29) | (3.16) | (2.62) | (2.83) | (3.73) | (5.83) | (6.95) | (7.51) | (7.19) |
| PCE inflation | 12.04 | 17.50 | 16.43 | 8.60 | 2.81 | 1.58 | 0.18 | 3.93 | 9.64 | 13.20 | 10.46 |
| | (6.33) | (5.63) | (4.71) | (3.58) | (2.91) | (2.85) | (3.48) | (4.72) | (6.00) | (5.63) | (5.59) |
| GDP inflation | 0.32 | 6.14 | 13.19 | 11.21 | 5.08 | 4.93 | 0.70 | 0.63 | 0.88 | 1.86 | 6.46 |
| | (5.53) | (4.82) | (4.14) | (3.64) | (3.28) | (2.52) | (2.53) | (2.72) | (3.54) | (5.13) | (5.75) |

| Variable X (without H-P filtered inflation) | $X_{t-5}$ | $X_{t-4}$ | $X_{t-3}$ | $X_{t-2}$ | $X_{t-1}$ | $X_t$ | $X_{t+1}$ | $X_{t+2}$ | $X_{t+3}$ | $X_{t+4}$ | $X_{t+5}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Chi-square test for equality of correlations across sample periods (1959:Q1 to 1979:Q3 and 1979:Q4 to 1998:Q4) | | | | | | | | | | |
| CPI inflation | 0.00 | 0.06 | 0.18 | 0.03 | 0.12 | 0.04 | 1.10 | 2.89 | 4.64 | 5.28 | 5.19 |
| | (5.98) | (7.33) | (6.34) | (6.40) | (5.17) | (4.24) | (4.68) | (4.73) | (4.57) | (4.41) | (4.19) |
| PCE inflation | 0.19 | 0.00 | 0.04 | 0.03 | 0.41 | 0.48 | 1.66 | 3.39 | 4.25 | 3.56 | 2.66 |
| | (6.17) | (9.30) | (11.06) | (12.31) | (11.82) | (6.76) | (6.22) | (5.14) | (4.36) | (4.37) | (4.17) |
| GDP inflation | 3.03 | 0.77 | 0.05 | 0.05 | 0.34 | 0.21 | 0.88 | 2.32 | 2.01 | 1.80 | 2.76 |
| | (5.25) | (8.78) | (10.86) | (12.69) | (12.32) | (8.52) | (7.53) | (6.62) | (4.59) | (4.31) | (4.49) |

NOTE: Simulated 10% critical values are shown in parentheses. The light shading indicates that the chi-square test statistic rejects stability at the asymptotic 10% critical value (2.71). The dark shading indicates that the chi-square test statistic is larger than the simulated 10% critical value.

and they change in approximately the same way as in the case of the filtered data. There is a significant decline in the positive correlations for CPI inflation at leads of three, four, and five quarters that are significant even when we use the more conservative critical values computed in the Monte Carlo simulations.

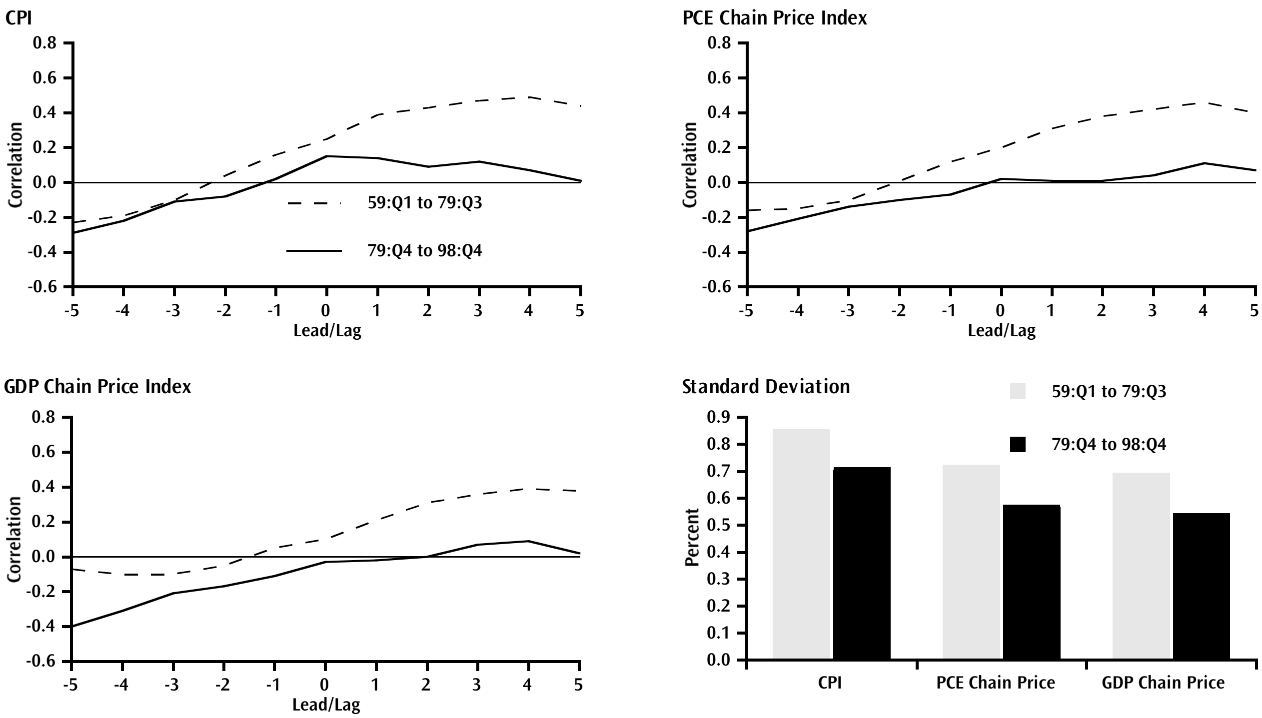
### *Interest Rates*

We conclude our discussion of the cyclical behavior of nominal variables with three market interest rates—the federal funds rate, the three-month Treasury bill rate, and the ten-year Treasury bond rate. As noted in the introduction, the method the Fed uses to implement FOMC policy decisions has an important effect on the time series properties of interest rates at high frequencies, days, weeks, months, and, perhaps, quarters. Although we investigated the effect of omitting the 1979:Q4 to 1982:Q3 data from all of our calculations, it only mattered in the case of inflation and interest rates. We will examine the post-1982:Q3 data for inflation in more detail in the next section. Here, we report cross-correlations between output and interest rates—both interest rates and output measured as deviations from the H-P trend—for three alternative periods: 1959:Q1 to 1979:Q3, 1979:Q4 to 1998:Q4, and 1982:Q4 to 1998:Q4.[10] Whether one should detrend interest rates depends on the

[10]Deleting the first three years has almost no effect on the measured cyclical pattern of the level variables examined in this study, except interest rates.

**Figure 6**

**Cyclical Properties of Inflation without H-P Filter**




question being asked of the data. Here, as was the case with inflation, we present the results both with and without the H-P filtering.

We begin by examining interest rates after removing the trend with the H-P filter. Figure 7 shows how the cyclical patterns changed after October 1979. Whether we omit the three-year period from 1979:Q4 to 1982:Q3 or not, there is a dampening of the correlations after October 1979. The large negative correlations at leads of four and five quarters rise for all three interest rates from about −0.7 in the period before October 1979 to a range between −0.4 and −0.6 in the period after October 1979. The dampening also occurs at lags of three to five quarters. The large positive correlations at these lags falls for all interest rates from about 0.6 in the period before October 1979 to a range between −0.07 and 0.34 in the latter period.

Stability tests with filtered interest rates are shown in the top panel of Table 5. The upper three rows report results when we break the sample in October 1979. We can reject the hypothesis that the correlations are stable across the October 1979 policy switch; 20 of 33 Wald statistics exceed the 10 percent critical value (2.71) implied by the theory for large samples. When we compute the small-sample distributions using the Monte Carlo method, however, we find that only in the case of the contemporaneous correlation between the ten-year rate and business sector output can we reject the hypothesis that the correlations are equal across the policy regimes.

The next three rows in the upper panel of Table 5 report the results when we delete the three years 1979:Q4 to 1982:Q3 from the second period. There is a dramatic increase in the correlations contemporaneously—and at a one-quarter lead (shown in Figure 7). The important differences that result from omitting the three-year interval can be seen in our Wald statistics. If we omit those three years and use the H-P filter on interest rates, then we can easily reject the hypothesis that the cyclical patterns are the same before and after October 1979. If we use the filter, the strongest rejections are of the leading correlations.

**Figure 7**

**Cyclical Properties of Nominal Interest Rates with H-P Filter**

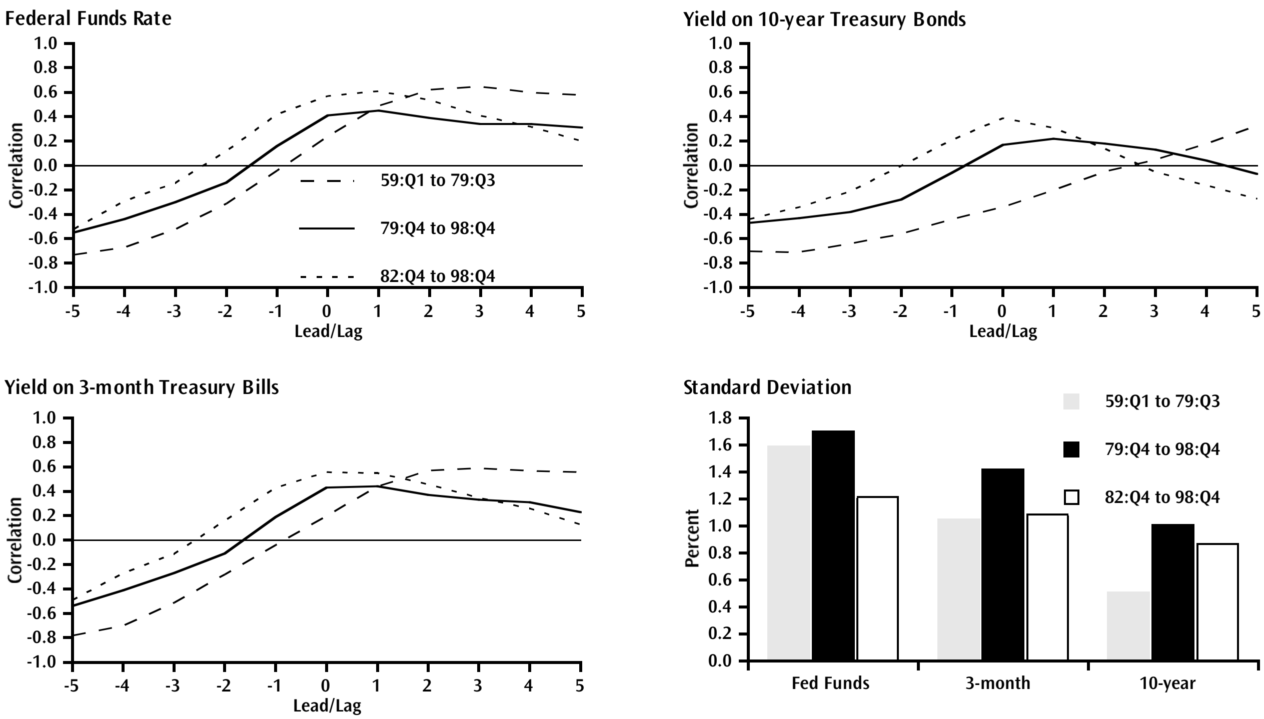



Figure 8 shows that, if we do not use the H-P filter, these interest rate correlations, compared with those in Figure 7, are about 0.3 to 0.4 smaller in absolute value in the first period and only about 0.1 smaller in the second period. Without the H-P filter, these correlations are about the same as those with the filter for the earlier period and are much lower than those for the latter period.

If we do not use the H-P filter, the leading correlations appear more similar across policy regimes, but the lagging correlations are significantly different. The bottom panel of Table 5 reports the tests for stability in this case. Using the asymptotic critical value of 2.71, we can reject stability for the leading correlations only in the case of the ten-year bond rate. On the other hand, we can reject stability in the lagging correlations for all three interest rates even when using the more conservative small-sample critical values.

The pattern for interest rates closely mimics the pattern for inflation. In all periods shown, interest rates have a negative correlation with output at leads, then turn positive both contemporaneously and at lags. The change in policy regime mainly raised the correlation at leads and lowered the correlation at lags. The changes in the patterns observed for inflation when not using the H-P filter (see Figure 6) are similar to the patterns we see when not using the H-P filter on interest rates.

## *Summary of Facts about the Cyclical Properties of Nominal Times Series*

The adoption of a disinflation policy in October 1979 does not appear to have had a measurable impact on the cyclical properties of real variables.. However, it made a dramatic difference in the cyclical properties of nominal variables. The cross-correlations between the monetary base and business sector output switched signs after the policy regime changed. Negative leads turned positive and positive lags became negative. For the other monetary aggregates, positive leads became smaller and usually insignificant. Generally, the monetary aggregates appear to be less cyclical after 1979.

Price indexes were generally countercyclical in

## Table 5

### Stability Tests for the Cyclical Properties of Nominal Interest Rates

**Chi-square test for equality of correlations across sample periods (1959:Q1 to 1979:Q3 and 1979:Q4 to 1998:Q4)**

| Variable X (H-P filtered inflation) | $X_{t-5}$ | $X_{t-4}$ | $X_{t-3}$ | $X_{t-2}$ | $X_{t-1}$ | $X_t$ | $X_{t+1}$ | $X_{t+2}$ | $X_{t+3}$ | $X_{t+4}$ | $X_{t+5}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Federal Funds Rate | 3.63 | 4.44 | 2.69 | 1.26 | 1.69 | 1.32 | 0.10 | 3.72 | 6.53 | 4.36 | 4.18 |
| | (10.08) | (6.65) | (3.97) | (2.50) | (2.18) | (2.61) | (3.80) | (6.96) | (12.00) | (11.29) | (9.73) |
| 3-month T-Bill | 7.14 | 7.31 | 3.15 | 1.21 | 2.07 | 2.39 | 0.00 | 2.71 | 4.15 | 3.97 | 5.89 |
| | (8.11) | (5.37) | (3.54) | (2.66) | (2.67) | (3.14) | (4.47) | (7.75) | (9.84) | (9.48) | (7.74) |
| 10-year T-Bond | 5.01 | 7.00 | 4.91 | 4.70 | 6.51 | 10.47 | 6.98 | 1.91 | 0.26 | 0.74 | 6.32 |
| | (10.61) | (10.10) | (9.94) | (8.84) | (8.34) | (7.79) | (17.41) | (7.10) | (7.77) | (8.35) | (8.99) |

**Chi-square test for equality of correlations across sample periods (1959:Q1 to 1979:Q3 and 1982:Q4 to 1998:Q4)**

| | $X_{t-5}$ | $X_{t-4}$ | $X_{t-3}$ | $X_{t-2}$ | $X_{t-1}$ | $X_t$ | $X_{t+1}$ | $X_{t+2}$ | $X_{t+3}$ | $X_{t+4}$ | $X_{t+5}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Federal Funds Rate | 2.05 | 4.70 | 5.50 | 4.37 | 3.81 | 5.00 | 1.94 | 0.05 | 2.40 | 5.27 | 5.35 |
| | (10.08) | (6.65) | (3.97) | (2.50) | (2.18) | (2.61) | (3.80) | (6.96) | (12.00) | (11.29) | (9.73) |
| 3-month T-Bill | 5.33 | 7.11 | 6.11 | 4.41 | 4.78 | 5.74 | 1.89 | 0.18 | 2.74 | 5.88 | 7.05 |
| | (8.11) | (5.37) | (3.54) | (2.66) | (2.67) | (3.14) | (4.47) | (7.75) | (9.84) | (9.48) | (7.74) |
| 10-year T-Bond | 3.94 | 6.08 | 6.90 | 8.96 | 10.45 | 13.82 | 11.46 | 3.15 | 0.04 | 3.81 | 10.80 |
| | (10.61) | (10.10) | (9.94) | (8.84) | (8.34) | (7.79) | (7.41) | (7.10) | (7.77) | (8.35) | (8.99) |

**Chi-square test for equality of correlations across sample periods (1959:Q1 to 1979:Q3 and 1979:Q4 to 1998:Q4)**

| Variable X (without H-P filtered inflation) | $X_{t-5}$ | $X_{t-4}$ | $X_{t-3}$ | $X_{t-2}$ | $X_{t-1}$ | $X_t$ | $X_{t+1}$ | $X_{t+2}$ | $X_{t+3}$ | $X_{t+4}$ | $X_{t+5}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Federal Funds Rate | 0.18 | 0.12 | 0.49 | 1.31 | 1.72 | 3.37 | 7.76 | 12.10 | 13.04 | 11.07 | 9.20 |
| | (9.22) | (9.45) | (8.74) | (7.16) | (5.46) | (6.42) | (7.70) | (7.92) | (6.85) | (6.74) | (7.24) |
| 3-month T-Bill | 0.61 | 0.47 | 1.35 | 2.60 | 2.48 | 3.29 | 6.86 | 10.33 | 10.72 | 9.86 | 9.47 |
| | (5.86) | (4.84) | (5.36) | (5.59) | (5.01) | (5.66) | (6.25) | (6.08) | (5.40) | (5.17) | (5.16) |
| 10-year T-Bond | 4.27 | 3.84 | 4.12 | 3.77 | 2.45 | 1.52 | 1.91 | 3.14 | 4.23 | 6.00 | 8.45 |
| | (47.25) | (28.81) | (12.32) | (3.95) | (2.70) | (8.91) | (16.70) | (22.95) | (23.45) | (19.01) | (11.09) |

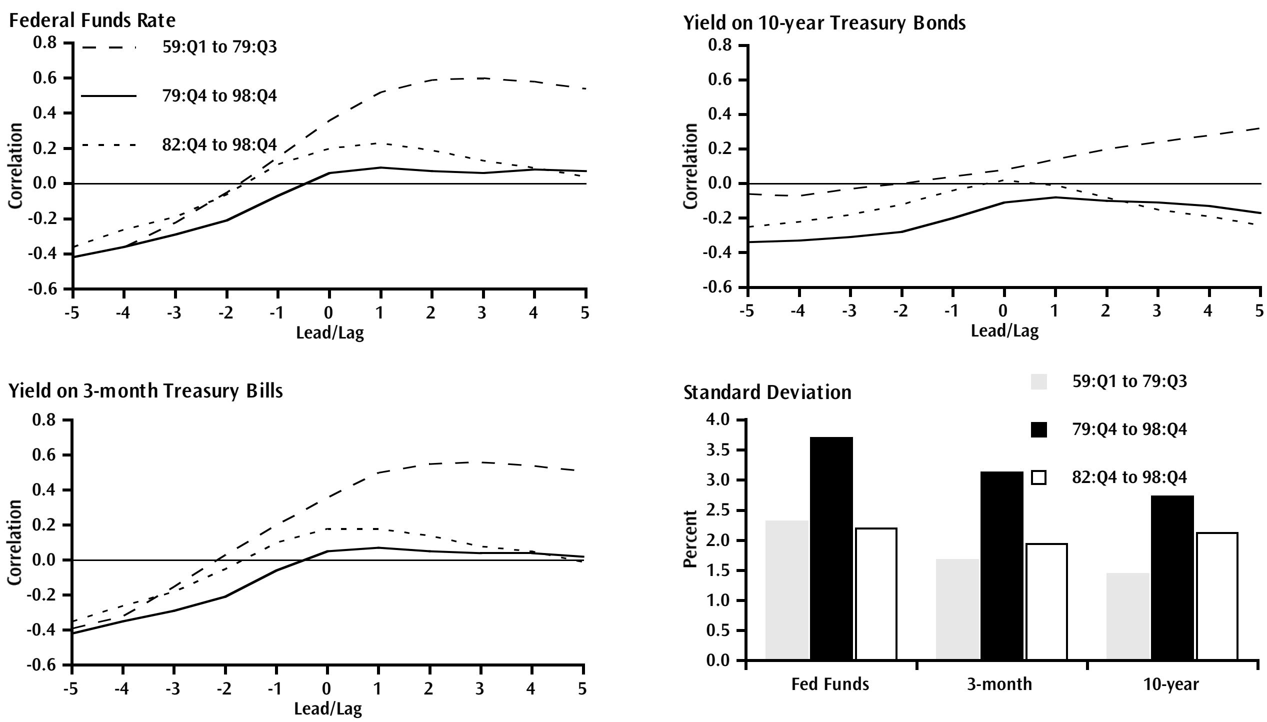
**Chi-square test for equality of correlations across sample periods (1959:Q1 to 1979:Q3 and 1982:Q4 to 1998:Q4)**

| | $X_{t-5}$ | $X_{t-4}$ | $X_{t-3}$ | $X_{t-2}$ | $X_{t-1}$ | $X_t$ | $X_{t+1}$ | $X_{t+2}$ | $X_{t+3}$ | $X_{t+4}$ | $X_{t+5}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Federal Funds Rate | 0.20 | 0.04 | 0.11 | 0.48 | 1.08 | 1.91 | 4.44 | 8.06 | 10.59 | 11.76 | 11.38 |
| | (9.22) | (9.45) | (8.74) | (7.16) | (5.46) | (6.42) | (7.70) | (7.92) | (6.85) | (6.74) | (7.24) |
| 3-month T-Bill | 0.50 | 0.29 | 0.54 | 1.15 | 1.43 | 1.92 | 4.08 | 7.73 | 9.83 | 11.30 | 11.80 |
| | (5.86) | (4.84) | (5.36) | (5.59) | (5.01) | (5.66) | (6.25) | (6.08) | (5.40) | (5.17) | (5.16) |
| 10-year T-Bond | 2.61 | 2.37 | 2.07 | 1.56 | 1.05 | 0.73 | 0.93 | 2.59 | 5.49 | 8.87 | 12.00 |
| | (47.25) | (28.81) | (12.32) | (3.95) | (2.70) | (8.91) | (16.70) | (22.95) | (23.45) | (19.01) | (11.09) |

NOTE: Simulated 10% critical values are shown in parentheses. The light shading indicates that the chi-square test statistic rejects stability at the asymptotic 10% critical value (2.71). The dark shading indicates that the chi-square test statistic is larger than the simulated 10% critical value.

**Figure 8**

**Cyclical Properties on Nominal Interest Rates without H-P Filter**




both periods, but the cross-correlations became smaller in absolute value after 1979 and the lead became longer. The absolute sizes of the negative correlations were largest between leads zero and two before October 1979 and between leads three and four in the period afterwards.

We examined the cyclical properties of inflation both with and without H-P filtering because both specifications are used in empirical studies of the aggregate supply function. Before October 1979 there is a strong cyclical pattern—a phase shift from the pattern observed for the price level. There is a relatively large negative correlation at leads and a large positive correlation at lags. After 1979, the pattern flattened for all the price indexes. The changes were highly significant. Without the H-P filter in the earlier period, the negative values at leads were close to zero and positive values at lags became as large as 0.4. After October 1979, the negative leads became somewhat larger, but contemporaneous and lagging correlations were close to zero. The cyclical patterns for market interest rates mirrored the patterns observed in the inflation rates.

## NOMINAL GROWTH RATES

In the previous section, we examined the business cycle properties of nominal variables using the H-P filter to define the cyclical component. In this section, we examine the relationship among nominal growth rates where the trends are determined by monetary policy. As we saw in Figure 1 and discussed in the introduction, policymakers allowed the inflation rate to drift upward over the period between 1959 and 1980. They appeared to be focused more sharply on the real variables than on controlling inflation. After October 1979, the Fed appeared to be putting relatively more weight on controlling inflation. We examine the covariance structure of data sets that contain growth rates of eight nominal variables: four measures of the money stock (SL Base, MZM, M2, and MSIM2), three price indexes (CPI, PCE chain price index, and the GDP chain price index), and nominal GDP. We begin by comparing simple descriptive statistics—means, standard deviations, and the autocorrelation functions—before and after the October 1979 policy switch. Next, we examine the cross-correlation functions between inflation and different measures of monetary growth. Before concluding, we also report the cross-correlations between nominal GDP and monetary growth.

For almost all of our results, omitting the period from October 1979 to October 1982 does not make much of a difference. We note the one case where there was an important difference. We decided to omit those three years in this section because

- it was a transition period when people were learning about the new policy regime;
- there were many regulatory changes during this period which caused abrupt shifts in the time series for measures of the money stock; and
- the nonborrowed reserve operating procedure affected the data at high frequencies and using a first-difference filter emphasizes the time series properties at high frequencies.

In all of the results reported for nominal growth rates, we are comparing statistics from the period 1959:Q1 to 1979:Q3 with the period from 1982:Q4 to 1998:Q4.

### *The Time-Series Properties of Money Growth, Inflation, and Nominal GDP Growth*

As we saw in Figure 1, the important aspect of the policy regime switch was the successful stabilization of inflation at a moderate rate. The average inflation rates were not that much different—the largest difference was in CPI inflation that averaged 4.2 percent in the first period and 3.2 percent in the second. However, there was a large increase in inflation from the early 1960s to the late 1970s, whereas the inflation rate was much more stable after 1982. There was a slight upward trend in the 1980s that reversed in the 1990s.

Somewhat surprisingly, average growth rates of the narrow measures of money, SL Base and MZM, are actually larger following the successful disinflation policy (see top panel of Figure 9). For the non-interest-bearing components of these narrow aggregates, this surprising result can be attributed partly to the one-time shift in the level demand for money that comes from a lower nominal interest rate. Nominal interest rates generally declined from 1982 until 1993. For example, the three-month Treasury bill rate declined from over 8 percent in the first half of 1983 to an average of about 3 percent in 1993. There was also a large demand from abroad for currency in the 1980s as the Soviet Union broke up and some high inflation countries in Latin America began to use more U.S. currency. For the interest-bearing components, the more rapid growth can be attributed to changes in regulations that allowed banks to pay interest on checkable deposits and offer easy access on demand for some savings-type deposits. These zero maturity deposits are included in MZM and grew rapidly after 1982. The two broad measures of money, M2 and the MSIM2, were lower in the second period.

The variability of the monetary growth rates is about the same or greater after 1982 than it was before 1979—much greater for MZM and slightly less for MSIM2 (see bottom panel of Figure 9). The variability of inflation and nominal GDP growth was substantially lower in the second period than it was in the first.

As shown in Figure 10, the autocorrelation coefficients for the growth rates of the narrow monetary aggregates, and all three measures of inflation, decay faster after 1982 than they do before October 1979. The autocorrelation functions for M2 and MSIM2 actually rise in the second period for lags of three quarters and higher. The largest shifts in autocorrelation functions for measures of the money stock occur in the cases of SL Base and M2 (see Table 6).

Table 6 shows that the shifts in the cases of the chain price indexes are generally not statistically significant if we use the Monte Carlo critical values. The most significant declines were in the autocorrelations of CPI inflation. This is the one case where excluding the three interim years, 1979:Q4 to 1982:Q3, was important. If we include these years, we find a more modest decline in the autocorrelation function except at the longest lags.

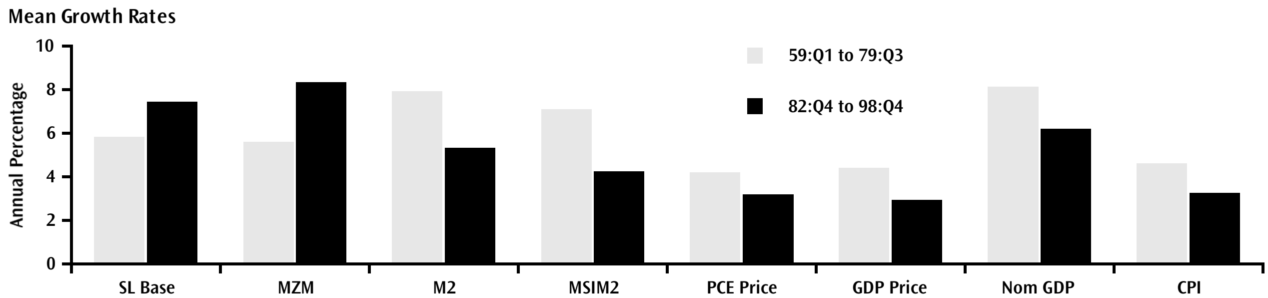
### *The Lag from Money to Prices*

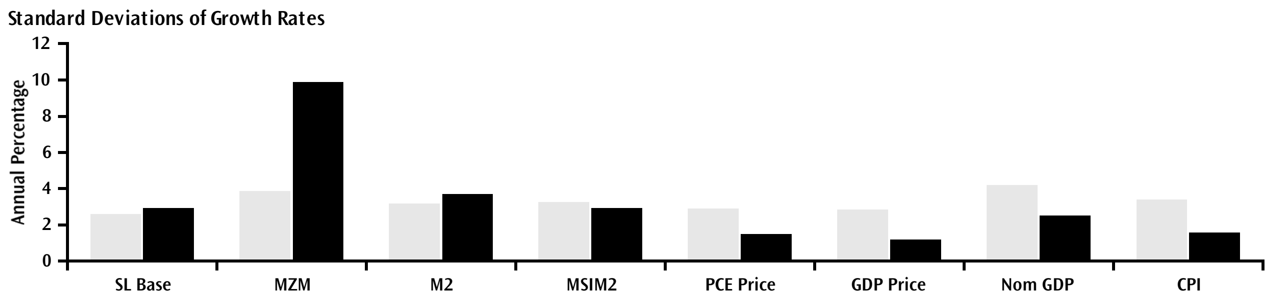
It is conventional wisdom among macroeconomists and policymakers that there is a long and variable lag between money and prices.[11] Work by Irving Fisher during the early part of this century indicated a much shorter lag than is typically found

[11] See Friedman (1961) for an influential discussion of this issue. Bryan and Gavin (1994) and Gavin and Kydland (1999) explore the possibility that the variable lag may be due to instability in the policy function.

**Figure 9**

### Statistics for Nominal Variables




in more recent studies. He thought the lag would be no longer than three months:

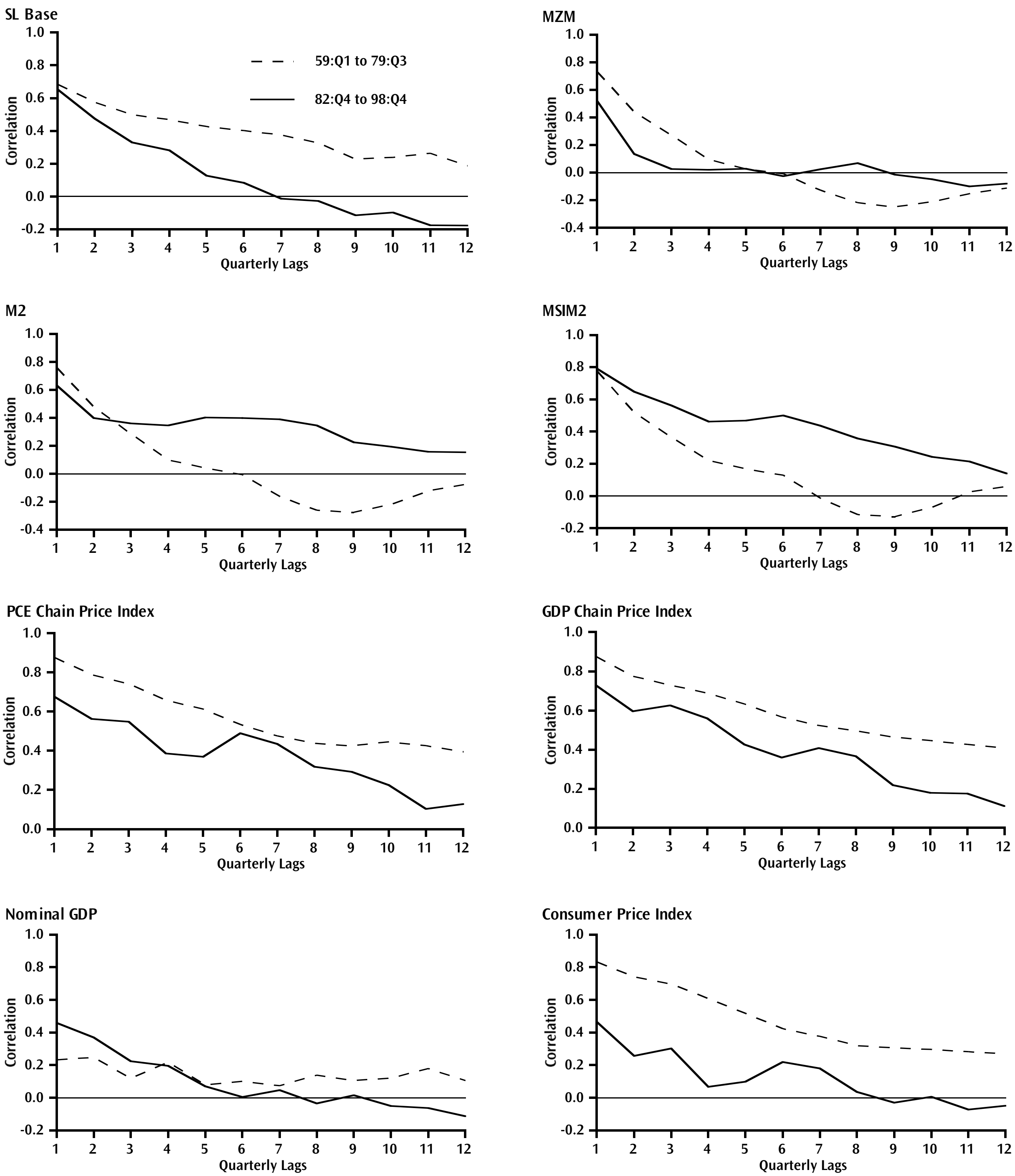
> It was in August, 1915, that the quantity of money in the United States began its rapid increase. One month later prices began to shoot upward, keeping almost exact pace with the quantity of money. In February, 1916, money suddenly stopped increasing, and two-and-a-half months later prices stopped likewise. Similar striking correspondences have continued to occur with an average lag between the money cause and the price effect of about one-and-three quarters months. (Fisher, 1918, p. 5)

In a recent study using U.S. data from the period from 1965:Q3 to 1995:Q2, Christiano, Eichenbaum, and Evans (1997) report that, following a contractionary monetary policy shock, "The GDP deflator is flat for roughly a year and a half after which it declines" (p. 23). One explanation for the difference in perceptions of the lag is the difference in monetary policy regimes. Our premise is that the variable lags reflect the expectation effects of variation in policy regimes.

That there will be differences in measures of the lag before and after 1980 is apparent in the data. The cross-correlations between CPI inflation and monetary growth are shown in Figure 11. As the upper left hand panel shows, quarterly series of monetary base growth and inflation were highly correlated in the period before October 1979. Afterwards, the cross-correlation between the two series is approximately zero for all lags from zero to twelve quarters. As Table 7 shows, the change in the cross-correlations between the monetary base and inflation are larger and more significant than the changes for any of the other aggregates. The values from the Wald test for equality of the correlation coefficients are larger than the Monte Carlo 10 percent critical values for the contemporaneous and 12 lags of monetary growth. The result is not as strong for the other aggregates, mainly because there was not much correlation between money and prices at short lags for MZM and the M2 measures. At lags of six quarters or more, the early period cross-correlations were relatively large and, using the theoretical asymptotic critical value, the correlations were all significantly smaller after 1982. However, only in

## Figure 10

### Autocovariance Functions for Nominal Variables



## Table 6

### Stability Tests for Autocorrelations in Nominal Growth Rates

| | Wald test for equality of autocorrelations across sample periods (1959:Q1 to 1979:Q3 and 1982:Q4 to 1998:Q4) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variable X | $X_{-1}$ | $X_{-2}$ | $X_{-3}$ | $X_{-4}$ | $X_{-5}$ | $X_{-6}$ | $X_{-7}$ | $X_{-8}$ | $X_{-9}$ | $X_{-10}$ | $X_{-11}$ | $X_{-12}$ |
| SL Base | 0.02 | 0.79 | 2.13 | 3.19 | 6.08 | 7.08 | 13.98 | 10.35 | 7.57 | 9.47 | 12.46 | 9.52 |
| | (7.65) | (7.16) | (6.45) | (5.17) | (5.37) | (5.68) | (5.74) | (6.19) | (6.18) | (5.60) | (6.14) | (6.21) |
| MZM | 4.31 | 4.83 | 2.95 | 0.14 | 0.04 | 0.01 | 0.96 | 0.88 | 1.74 | 3.39 | 0.01 | 0.19 |
| | (4.12) | (4.73) | (5.59) | (6.25) | (5.89) | (6.24) | (5.67) | (5.94) | (5.86) | (6.15) | (5.98) | (5.94) |
| M2 | 1.66 | 0.05 | 1.12 | 4.91 | 9.68 | 9.86 | 19.98 | 19.80 | 15.24 | 14.77 | 6.31 | 4.52 |
| | (6.46) | (8.55) | (9.48) | (9.75) | (7.52) | (7.09) | (6.79) | (6.82) | (6.33) | (6.23) | (5.85) | (6.07) |
| MSIM2 | 0.34 | 1.52 | 2.18 | 2.70 | 4.39 | 8.33 | 10.58 | 11.09 | 8.58 | 3.90 | 1.86 | 0.73 |
| | (9.99) | (11.42) | (13.00) | (14.39) | (13.05) | (11.42) | (11.52) | (10.52) | (10.24) | (11.35) | (10.33) | (10.10) |
| PCE Chain | 13.45 | 10.28 | 5.03 | 5.69 | 3.74 | 0.05 | 0.05 | 0.75 | 0.71 | 2.03 | 4.03 | 3.29 |
| Price Index | (11.22) | (11.43) | (9.98) | (12.86) | (10.39) | (9.88) | (11.12) | (10.18) | (9.95) | (9.84) | (9.05) | (8.44) |
| GDP Chain | 6.29 | 4.45 | 0.82 | 1.51 | 2.48 | 1.36 | 0.44 | 0.83 | 1.62 | 1.44 | 1.44 | 1.78 |
| Price Index | (13.51) | (16.63) | (12.24) | (11.34) | (15.14) | (13.29) | (12.28) | (12.62) | (12.22) | (11.95) | (11.49) | (11.45) |
| GDP | 2.49 | 0.43 | 0.26 | 0.18 | 1.02 | 2.44 | 0.81 | 3.57 | 0.00 | 0.20 | 0.19 | 0.14 |
| | (6.67) | (3.69) | (4.57) | (2.84) | (2.80) | (2.69) | (2.63) | (2.61) | (3.07) | (2.80) | (2.69) | (2.99) |
| CPI | 27.01 | 32.59 | 20.51 | 21.94 | 17.49 | 8.81 | 6.22 | 8.37 | 6.88 | 4.38 | 8.83 | 6.90 |
| | (4.73) | (5.14) | (4.90) | (5.45) | (4.40) | (4.52) | (4.95) | (4.31) | (4.29) | (4.32) | (4.10) | (4.04) |

NOTE: Simulated 10% critical values are shown in parentheses. The light shading indicates that the Wald statistic rejects stability at the asymptotic 10% critical value (2.71). The dark shading indicates that the Wald statistic is larger than the simulated 10% critical value.

the case of M2 can we consistently reject equality across the two periods using the more conservative Monte Carlo critical values.

In the early period, monetary policy allowed the average inflation rate to ratchet upward with each business cycle. This policy was associated with high variances in nominal growth rates and high cross-correlations between monetary base growth and inflation. When the Fed adopted a successful policy to stabilize inflation at a moderate rate, the cross-correlations with the monetary base went to zero and the autocorrelations of inflation measures decayed more quickly.

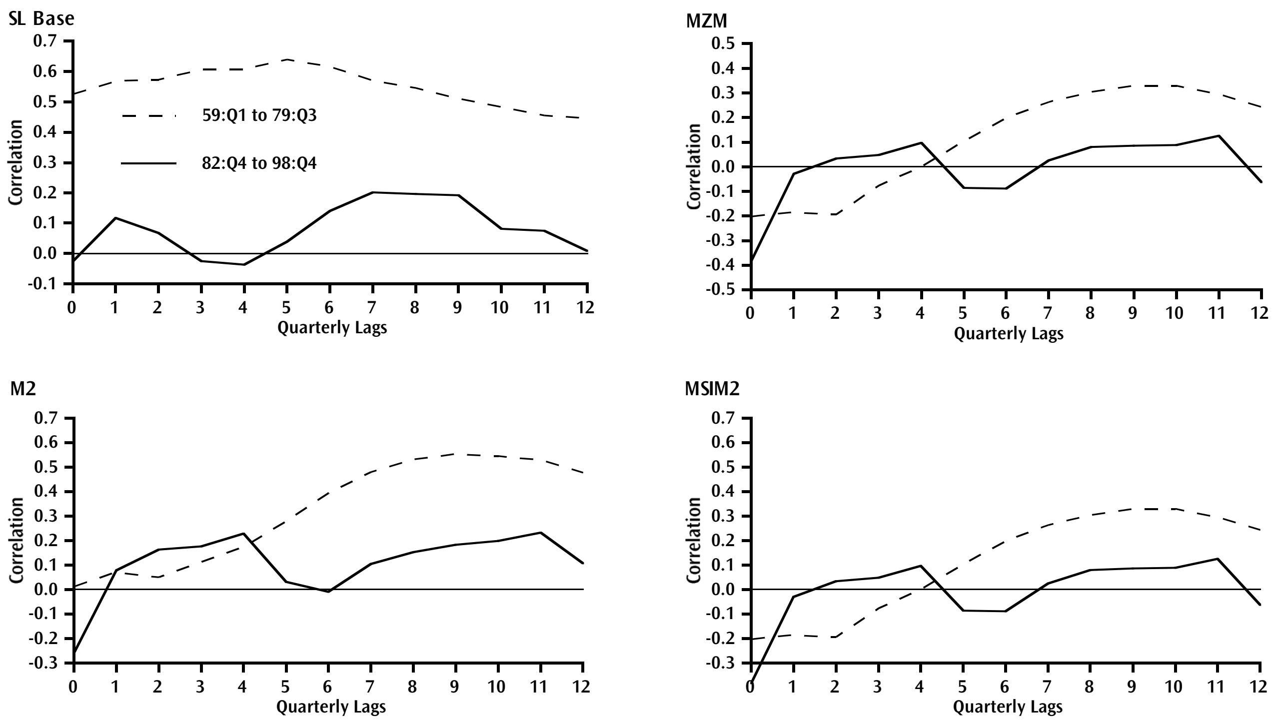
### *The Lag from Money to Nominal GDP*

Many economists supported monetary targeting in the 1970s because of the close relationship between growth rates of the money stock and nominal GDP. The St. Louis equation developed by Andersen and Jordan (1968) was based on this relationship and was the foundation for many small forecasting models until the early 1980s. The breakdown in the relationship between money and nominal output then led many economists to lose confidence in the reliability of monetary targeting as a strategy for running policy.

In earlier sections, we documented a dramatic shift in the cyclical behavior of the monetary aggregates and a significant shift in the relationship between money growth and inflation. Therefore, we also expected to see a change in the cross-correlations between nominal GDP growth and monetary growth. As Figure 12 shows, this was the case with the SL Base and MSIM2, but not with

## Figure 11

### Cross-Correlations between CPI Inflation and Monetary Growth




## Table 7

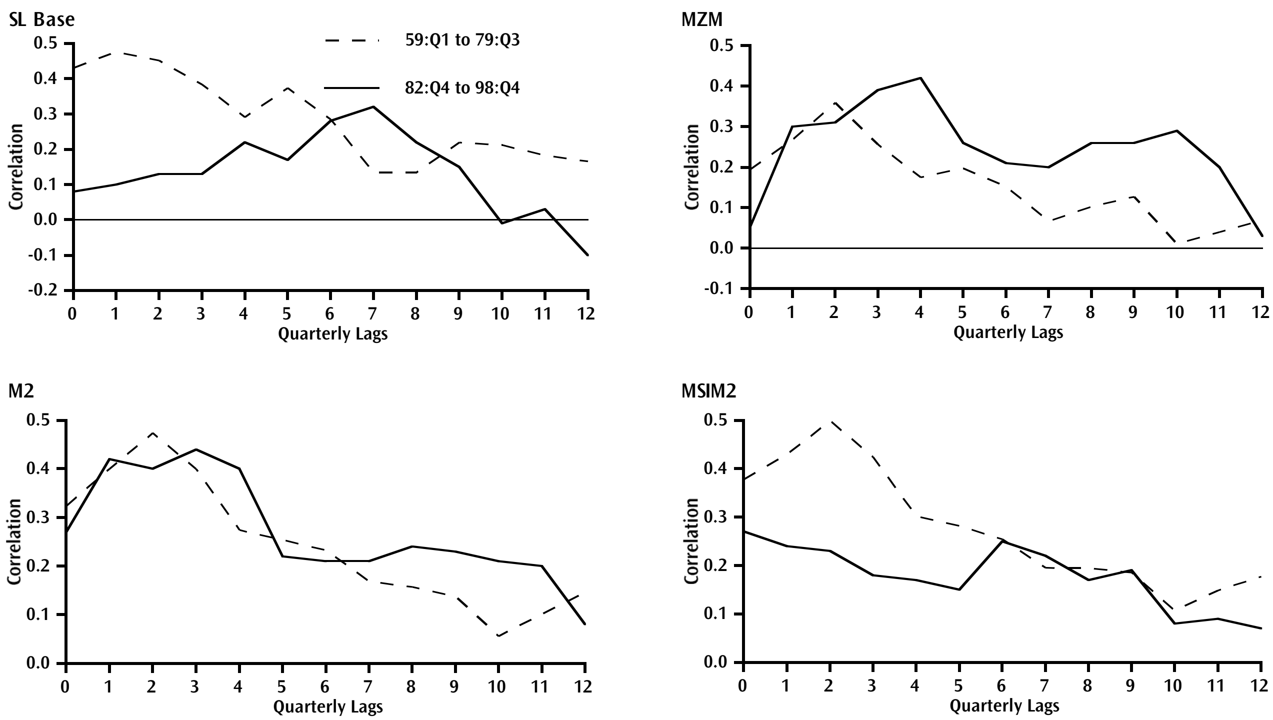
### Stability Tests for the Cross-correlations between Inflation and Monetary Growth

| Variable X | Wald test for equality of correlations across sample periods (1959:Q2 to 1979:Q3 and 1982:Q4 to 1998:Q4) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $X_0$ | $X_{-1}$ | $X_{-2}$ | $X_{-3}$ | $X_{-4}$ | $X_{-5}$ | $X_{-6}$ | $X_{-7}$ | $X_{-8}$ | $X_{-9}$ | $X_{-10}$ | $X_{-11}$ | $X_{-12}$ |
| SL Base | 12.63 | 10.25 | 12.60 | 16.97 | 19.37 | 18.01 | 14.19 | 8.72 | 8.49 | 11.57 | 12.20 | 8.48 | 16.26 |
| | (7.11) | (6.36) | (6.74) | (6.47) | (6.74) | (6.46) | (6.33) | (6.22) | (6.40) | (6.19) | (6.37) | (5.95) | (6.58) |
| MZM | 1.36 | 0.81 | 1.82 | 0.62 | 0.23 | 1.37 | 3.13 | 2.30 | 1.48 | 3.92 | 4.10 | 1.03 | 4.43 |
| | (4.04) | (4.69) | (4.51) | (4.47) | (5.19) | (4.84) | (4.33) | (4.40) | (4.07) | (4.20) | (4.79) | (4.29) | (4.36) |
| M2 | 2.64 | 0.00 | 0.20 | 0.01 | 0.00 | 2.78 | 6.75 | 6.87 | 6.84 | 8.78 | 8.45 | 5.32 | 8.70 |
| | (7.16) | (6.71) | (6.96) | (7.06) | (7.32) | (6.45) | (5.77) | (6.27) | (6.44) | (6.13) | (6.09) | (6.34) | (6.69) |
| MSIM2 | 1.35 | 0.38 | 0.07 | 0.99 | 1.04 | 3.13 | 6.35 | 7.24 | 8.00 | 10.79 | 8.34 | 4.94 | 5.29 |
| | (9.56) | (9.76) | (8.87) | (8.97) | (10.15) | (9.83) | (9.47) | (10.30) | (9.97) | (9.35) | (9.59) | (9.48) | (9.72) |

NOTE: Simulated 10% critical values are shown in parentheses. The light shading indicates that the Wald statistic rejects stability at the asymptotic 10% critical value (2.71). The dark shading indicates that the Wald statistic is larger than the simulated 10% critical value.

## Figure 12

### Cross-Correlations between Nominal GDP Growth and Monetary Growth




## Table 8

### Stability Tests for the Cross-correlations between Nominal GDP Growth and Monetary Growth

| Variable X | Wald test for equality of correlations across sample periods (1959:Q2 to 1979:Q3 and 1982:Q4 to 1998:Q4) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $X_0$ | $X_{-1}$ | $X_{-2}$ | $X_{-3}$ | $X_{-4}$ | $X_{-5}$ | $X_{-6}$ | $X_{-7}$ | $X_{-8}$ | $X_{-9}$ | $X_{-10}$ | $X_{-11}$ | $X_{-12}$ |
| SL Base | 4.62 | 6.15 | 4.32 | 2.27 | 0.38 | 2.27 | 0.84 | 0.07 | 0.69 | 2.79 | 4.41 | 1.69 | 6.81 |
| | (2.77) | (3.11) | (3.89) | (3.66) | (3.78) | (3.53) | (3.75) | (4.02) | (4.09) | (3.67) | (3.89) | (3.70) | (3.68) |
| MZM | 0.72 | 0.02 | 0.50 | 0.22 | 1.11 | 0.01 | 0.01 | 0.36 | 0.33 | 0.03 | 1.31 | 0.52 | 0.67 |
| | (2.63) | (2.63) | (2.83) | (3.28) | (2.96) | (3.16) | (3.54) | (3.25) | (3.43) | (3.29) | (3.44) | (3.26) | (3.30) |
| M2 | 0.11 | 0.01 | 0.59 | 0.00 | 0.62 | 0.01 | 0.04 | 0.52 | 1.22 | 0.83 | 2.43 | 1.81 | 0.03 |
| | (2.17) | (2.13) | (2.36) | (2.22) | (2.11) | (2.17) | (2.33) | (2.19) | (2.22) | (2.34) | (2.44) | (2.27) | (2.23) |
| MSIM2 | 0.48 | 1.86 | 4.57 | 2.68 | 0.24 | 0.12 | 0.03 | 0.08 | 0.01 | 0.14 | 0.02 | 0.01 | 0.32 |
| | (2.08) | (2.41) | (2.51) | (2.30) | (2.14) | (2.36) | (2.51) | (2.67) | (2.46) | (2.47) | (2.47) | (2.29) | (2.88) |

NOTE: Simulated 10% critical values are shown in parentheses. The light shading indicates that the Wald statistic rejects stability at the asymptotic 10% critical value (2.71). The dark shading indicates that the Wald statistic is larger than the simulated 10% critical value.

MZM or M2. In the earlier period, growth in nominal GDP was correlated with contemporaneous SL base growth and lagged SL base growth for approximately the previous six quarters. The correlation was highest—nearly 0.5—at the first lag and tapered off to values of 0.2 or lower at longer lags. In the second period, the contemporaneous correlation was 0.1 and rose gradually to peak around 0.3 at lag seven and then fell to zero at lag ten. In the case of MSIM2, the cross-correlations at short lags were lower in the second period. As shown in Table 8, the Wald test rejects equality at the second and third lags.

### *Summary of Facts about Nominal Growth Rates*

Generally, monetary policy in the early period allowed the average inflation rate to ratchet upward with each business cycle. This policy was associated with high variances, high autocorrelations, and high cross-correlations among nominal variables. The moderate inflation policy that followed in the second period was associated with lower mean growth rates, less volatility, and lower cross-correlations.

The cross-correlations between nominal GDP growth and growth in MZM and M2 seem to be approximately the same across the October 1979 regime switch. The biggest differences were in the cross-correlations with the monetary base.

## CONCLUSION

There are important implications of this paper for building monetary models. Our results show that researchers should take care when they assume that the covariance structure of data sets is stationary. Our results suggest that is generally not the case for nominal time series spanning a time period that includes October 1979. The strategy of modern macroeconomics is to build general equilibrium models and compare the covariance structure of data implied by the model to the covariance structure observed in the data. Large deviations signal areas for further research. This research strategy has worked better in real business cycle studies because the covariance structure of real variables seem to be relatively stable across countries and policy regimes. It has not worked so well in monetary business cycles because there is no general agreement about the facts. Our results suggest that one way to find regularities in the data may be to examine and compare episodes with similar monetary policy regimes.

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